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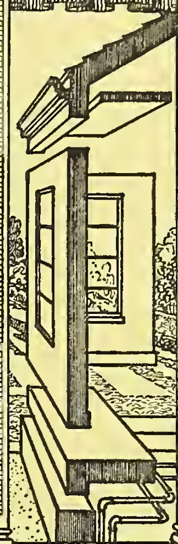


BUILDING MATERIALS AND STRUCTURES

REPORT BMS16

Structural Properties of a "Tilecrete" Floor Construction Sponsored by Tilecrete Floors, Inc.

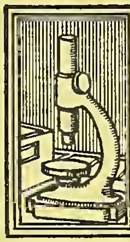
by

HERBERT L. WHITTEMORE

AMBROSE H. STANG, *and*

CYRUS C. FISHBURN

NATIONAL BUREAU OF STANDARDS



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ISSUED MARCH 24, 1939

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Foreword

This report is one of a series issued by the National Bureau of Standards on the structural properties of constructions intended for low-cost houses and apartments. Practically all of these constructions were sponsored by groups within the building industry which advocate and promote the use of such constructions and which have built and submitted representative specimens as outlined in report BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions. The sponsor is responsible for the representative character of the specimens and for the detailed description given in each report. The Bureau is responsible for the accuracy of the test data.

This report covers only the load-deformation relations and strength of the structural element submitted when subjected to transverse, impact, and concentrated loads by standardized methods simulating the loads to which the element would be subjected in actual service. It may be feasible to determine later the heat transmission at ordinary temperatures and the fire resistance of this same construction and perhaps other properties.

The National Bureau of Standards does not "approve" a construction, nor does it express an opinion as to the merits of a construction, for reasons given in reports BMS1 and BMS2. The technical facts on this and other constructions provide the basic data from which architects and engineers can determine whether a construction meets desired performance requirements.

Lyman J. Briggs, *Director.*

Structural Properties of a "Tilecrete" Floor Construction Sponsored by Tilecrete Floors, Inc.

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CONTENTS

ABSTRACT

For the program on the determination of the structural properties of low-cost house constructions, Tilecrete Floors, Inc., submitted six specimens representing their "Tilecrete" floor construction.

The specimens were subjected to transverse, impact, and concentrated loads. For each of these loads three like specimens were tested, the concentrated-load tests being made on undamaged portions of the specimens used for the impact tests. The deformation under load and the set after the load was removed were measured for uniform increments of load, except for concentrated loads, for which the set only was determined. The strength under transverse load was also determined. The results are presented graphically and in a table.

I. INTRODUCTION

In order to provide technical facts on the performance of constructions which might be used in low-cost houses, to discover promising constructions, and ultimately to determine the properties necessary for acceptable performance, the National Bureau of Standards has invited the building industry to cooperate in a program of research on building materials and structures for use in low-cost houses and apartments. The objectives of this program are described in report BMS1, Research on Building Materials and Structures for Use in Low-Cost Housing,[1] and that part of the program relating to structural properties in report BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions.[2]

Conventional wood-frame constructions, including those for floors, have been subjected by the Forest Products Laboratory of the United States Department of Agriculture to a series of standardized laboratory tests to provide data on the properties of some constructions for which the behavior in service is generally known. These data will be given in a subsequent report in this series.

This report describes the structural properties of a floor construction sponsored by one of the manufacturers in the building industry. The specimens were subjected to transverse, impact, and concentrated loads, simulating loads to which the floor of a house is subjected. In actual service, transverse loads are applied to floors by furniture and by the occupants; impact loads by objects falling on the floor or by persons jumping on the floor; and concentrated loads by furniture, for example, the legs of a piano.

The deformation and set under each increment of load were measured because the suitability of a floor construction depends in part on its resistance to deformation under load and whether it returns to its original size and shape when the load is removed.

[1] Price 10 cents. See cover page II.

[2] Price 10 cents.

1–6680°—39

II. SPONSOR AND PRODUCT

The specimens were submitted by Tilecrete Floors, Inc., St. Louis, Mo., and represented their "Tilecrete" floor construction. The floor construction consisted of expanded steel joists, tile fillers, concrete fill, and a wood-block finish floor.

III. SPECIMENS AND TESTS

The floor construction was assigned the symbol *AW*, and the specimens were assigned designations in accordance with table 1.

TABLE 1.—*Specimen designations*

Specimen designation	Load	Load applied
T1, T2, T3	Transverse	Upper face.
I1, I2, I3	Impact	Do.
P1, P2, P3[a]	Concentrated	Do.

[a] These specimens were undamaged portions of the specimens used fo the impact tests.

The specimens were tested in accordance with BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions.[3] This report also gives the requirements for the specimens and describes the presentation of the results of the tests, particularly the load-deformation graphs.

The specimens were tested on May 2 and 3, 1938, when the age of the concrete fill was 28 days. The sponsor's representative witnessed the tests.

IV. FLOOR *AW*

1. SPONSOR'S STATEMENT

(a) *Materials*

Steel.—Open-hearth, hot-rolled, **I**-beams made by the Carnegie-Illinois Steel Co. The chemical composition of the steel is given in table 2 and the mechanical properties in table 3.

TABLE 2.—*Chemical composition of the steel*

Element	Content
	Percent
Carbon	0.19
Manganese	.46
Phosphorus	.010
Sulfur	.028

[3] Price 10 cents.

TABLE 3.—*Mechanical properties of the steel*

Yield point	Tensile strength	Elongation in 8 in.
lb/in.²	*lb/in.²*	*Percent*
37,070	62,540	29

The **I**-beams were expanded hot to form joists by the Bates Expanded Steel Corp. The joists were straightened by rerolling.

Welds.—Arc welds made with low-carbon welding rods.

Tile.—Special structural clay floor tile, four-cell, 4 by 16½ by 12 in., as shown in figure 1, of northern surface clay, shell thickness ¾ in., web thickness ⅝ in.; compressive strength on end, 3,500 lb/in.² of net area. "Half" tile, 4 by 8 9/16 by 12 in., were cut from full-size tile to include the entire center web.

The absorption of the tile, determined by the Masonry Construction Section of the National Bureau of Standards in accordance with the American Society for Testing Materials Standard C 112–36,[4] was 21.8 percent for the 24-hr

[4] Am. Soc. Testing Materials Standards, pt. 2, p. 183–186 (1936).

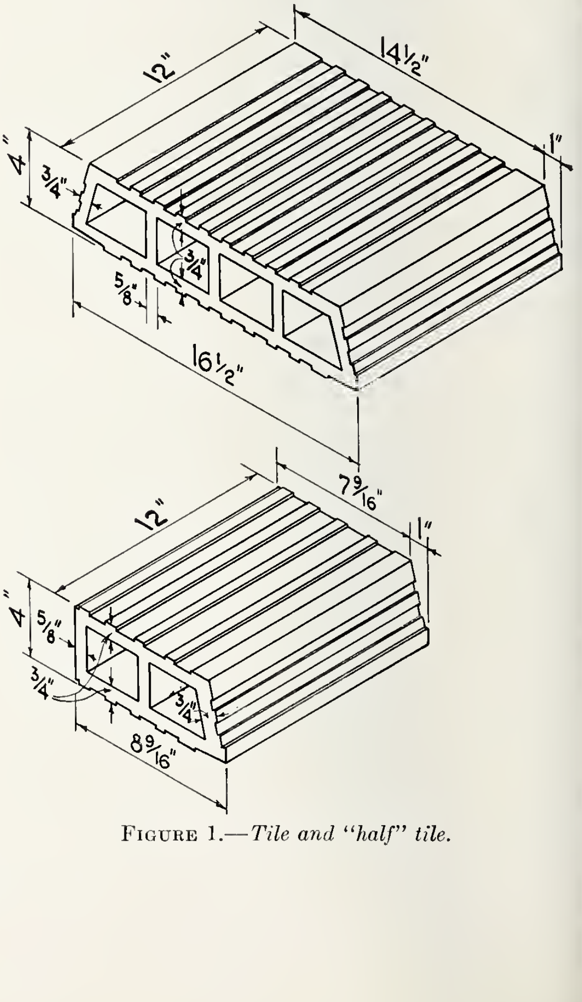

FIGURE 1.—*Tile and "half" tile.*

cold test and 22.3 percent for the 1-hr boil test.

Concrete.—Truck-mixed, containing 1 part portland cement, 2.5 parts dry sand, and 4 parts dry gravel, by weight. The concrete was delivered in two batches.

The following properties of the concrete were determined by the Masonry Construction Section of the National Bureau of Standards. For each batch the slump was determined and six 6- by 12-in. cylinders were made. Three cylinders were cured with the floor specimens and the other three were stored in the concrete-curing room at 70° F and relative humidity of 95 to 100 percent. The compressive strength of the cylinders was determined on the day the corresponding floor specimens were tested, at an age of 28 days. The physical properties of the concrete are given in table 4.

TABLE 4.—*Physical properties of the concrete*

Batch	Slump	Compressive strength	
		Cylinders cured with floor specimens	Cylinders stored in concrete-curing room
	in.	*lb/in.²*	*lb/in.²*
1	7¾	2,150	2,290
2	8¼	2,320	2,930

Mastic.—Asphalt base. E. L. Bruce Co.

Wood.—Oak, red, clear, plain-sawed, parquetry flooring, 9- by 9-in. blocks, consisting of four strips of 25/32- by 2¼-in. tongued-and-grooved flooring, fastened together by glue and by two sheet-steel splines in kerfs in the bottom of each block. E. L. Bruce Co.'s "Bruce Finished Block."

(*b*) *Description*

The floor specimens were 12 ft 6 in. long, 4 ft 5 in. wide, and 6⅞ in. thick. Each specimen consisted of three steel joists, *A*, as shown in figure 2, with structural-clay-tile fillers, *B*, and a concrete fill, *C*. The fill was covered with mastic, *D*, on which a wood parquetry finish floor, *E*, was laid.

The price of this construction in Washington, D. C., as of July 1937, was $0.37/ft².

Joists.—The joists, *A*, were expanded steel **I**-beams, 6 by 1½ in., 12 ft 6 in. long, 4.22 lb/ft, "Bonderized" finish. The joists had stiffeners welded to each end, as shown in figure 3.

Tile fillers.—Tile fillers, *B*, were placed between the joists, and "half" tile along each edge of the specimen.

Fill.—The fill, *C*, was concrete, 2 in. thick, screeded level with the upper flanges of the joists. The concrete was batch 1 for specimens *I1*, *I2*, and *T1* and batch 2 for specimens *I3*, *T2*, and *T3*.

Mastic.—Mastic, *D*, was applied with a brush to the upper face of the specimen.

Finish floor.—The finish floor, *E*, consisted of wood-block flooring laid in the mastic.

(*c*) *Comments*

"Tilecrete" floors have been used in approximately 280 buildings up to October 1, 1938.

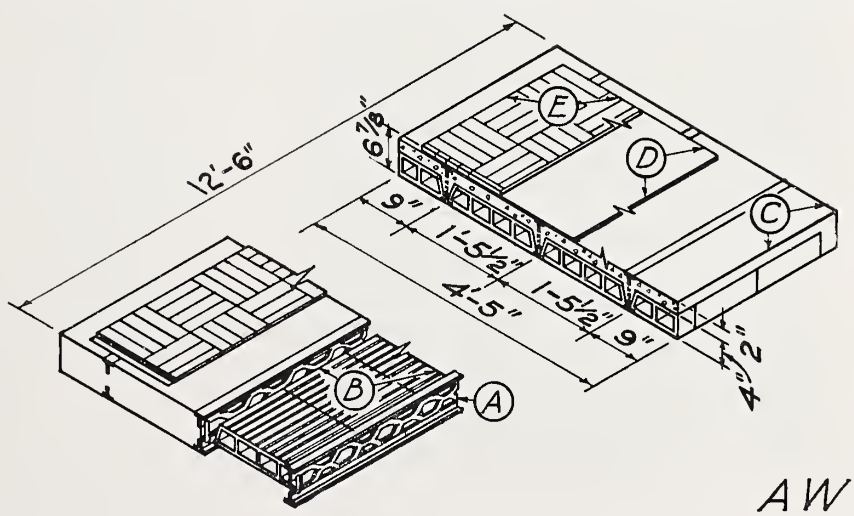

FIGURE 2.—*Floor specimen AW.*

A, joist; *B*, tile filler; *C*, fill; *D*, mastic; *E*, finish floor.

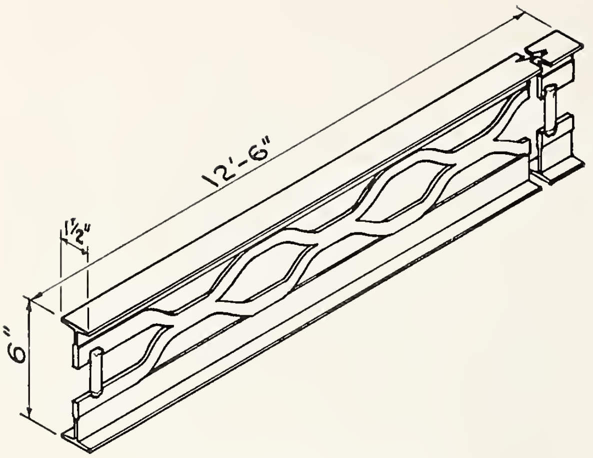

Figure 3.—*Expanded steel joist.*

About 80 percent of these buildings were dwellings.

The joists are designed to be framed into conventional masonry or steel buildings without the use of temporary supports during erection. Plumbing, electric conduit, and air ducts may be placed in the floor before the concrete fill is poured. The concrete fill is poured directly on the tile and steel without the use of forms. Any type of finish floor may be used over the concrete fill. Typical finish floors are (a) wood blocks laid in mastic, (b) wood flooring fastened to wood sleepers set in the concrete, (c) linoleum, (d) concrete, (e) terrazzo, and (f) floor tile.

The ceiling may be finished with plaster applied in two coats. The scratch coat containing fibered plaster is applied directly to the tile. The usual white finish coat is applied over the scratch coat.

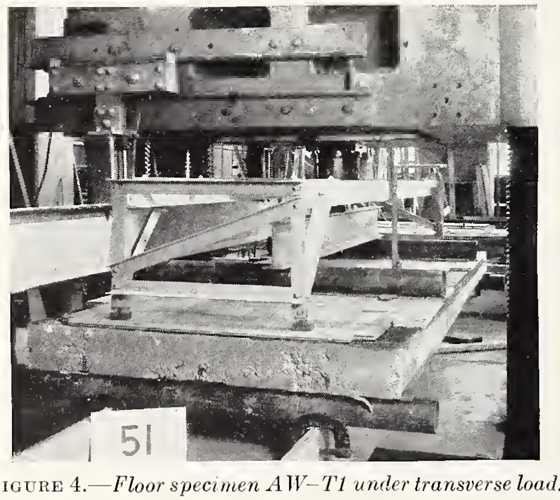

Figure 4.—*Floor specimen AW–T1 under transverse load.*

2. Transverse Load

Floor specimen *AW–T1* under transverse load is shown in figure 4. The results for floor specimens *AW–T1*, *T2*, and *T3* are shown in table 5 and in figure 5.

Table 5.—*Structural properties of floor AW*

[Weight, 51.5 lb/ft²]

Load	Load applied	Specimen designation	Maximum height of drop	Maximum load
			ft	*lb/ft²*
Transverse	Upper face; span, 12 ft 0 in.	*T1*		435
		T2		438
		T3		444
	Average			439
				lb
Concentrated	Upper face	*P1*		[a]1000
		P2		[a]1000
		P3		[a]1000
	Average			[a]1000
Impact	Upper face; span, 12 ft 0 in.	*I1*	[a]10.0	
		I2	[a]10.0	
		I3	[a]10.0	
	Average		[a]10.0	

[a] Specimen did not fail.

Each of the specimens failed by yielding of the lower flanges of the joists, as indicated by

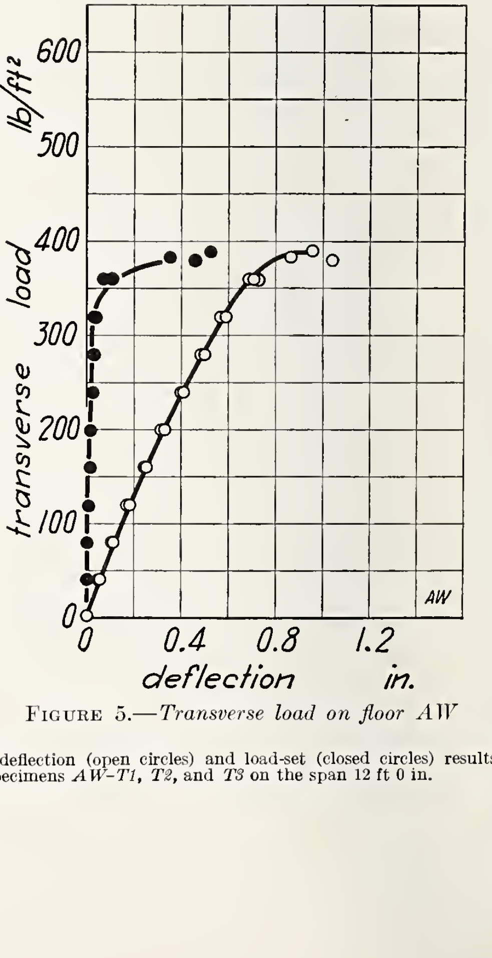

Figure 5.—*Transverse load on floor AW*

Load-deflection (open circles) and load-set (closed circles) results for specimens *AW–T1*, *T2*, and *T3* on the span 12 ft 0 in.

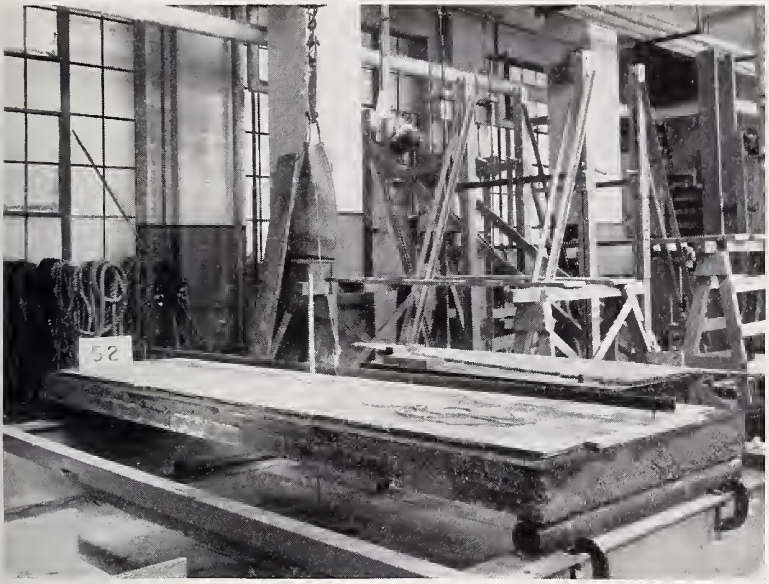

FIGURE 6.

Floor specimen AW–I1 under impact load.

Lüders' lines, followed by cracking of some of the tile fillers and cracking of the concrete fill at joints between the tiles. The Lüders' lines were observed at loads of 390, 383, and 360 lb/ft ^{2} for specimens *T1*, *T2*, and *T3*, respectively. In addition, for specimen *T2* the finish floor separated from the concrete fill between the loading rollers.

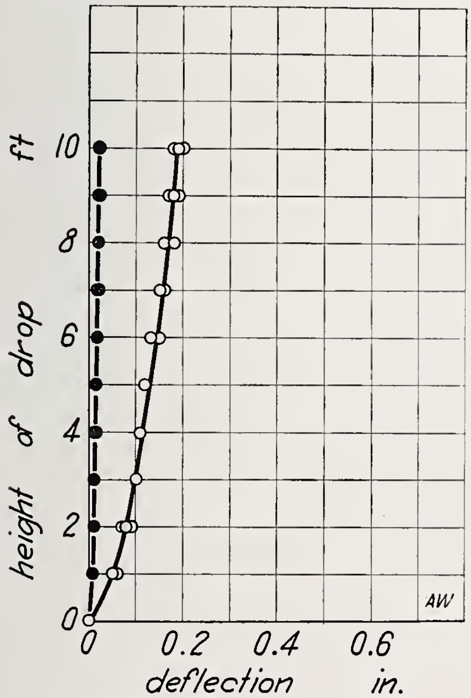

FIGURE 7.—*Impact load on floor AW.*

Height of drop-deflection (open circles) and height of drop-set (closed circles) results for specimens *AW–I1*, *I2*, and *I3* on the span 12 ft 0 in.

3. IMPACT LOAD

Floor specimen *AW–I1* during the impact test is shown in figure 6. The results for floor specimens *AW–I1*, *I2*, and *I3* are shown in table 5 and in figure 7.

The impact loads were applied to the center of the upper face of each specimen so that the sandbag struck the finish floor directly over the

FIGURE 8.—*Floor specimen AW–P2 under concentrated load.*

center joist. The sets after a drop of 10 ft were 0.023, 0.021, and 0.022 in. for specimens *I1*, *I2*, and *I3*, respectively, and no other effect was observed.

4. Concentrated Load

Floor specimen *AW–P2* under concentrated load is shown in figure 8. The results for floor specimens *AW–P1*, *P2*, and *P3* are shown in table 5 and in figure 9.

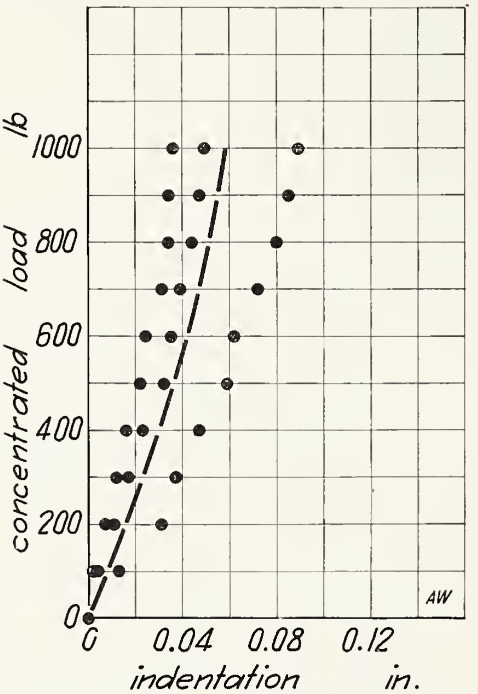

Figure 9.—*Concentrated load on floor AW.*

Load-indentation results for specimens *AW–P1*, *P2*, and *P3*.

The concentrated loads were applied to the finish floor of each specimen near a corner of one of the inner blocks of flooring. The indentations after a load of 1,000 lb had been applied were 0.089, 0.049, and 0.036 in. for specimens *P1*, *P2*, and *P3*, respectively, and no other effect was observed.

The sponsor supplied the information contained in the sponsor's statement. The drawings of the specimens were prepared by E. J. Schell and G. W. Shaw of the Bureau's Building Practice and Specifications Section, under the supervision of V. B. Phelan. That Section also cooperated in the preparation of the report.

The structural properties were determined by the Engineering Mechanics Section, under the supervision of H. L. Whittemore and A. H. Stang, and the Masonry Construction Section, under the supervision of D. E. Parsons, with the assistance of the following members of the professional staff: C. C. Fishburn, F. Cardile, R. C. Carter, H. Dollar, M. Dubin, A. H. Easton, A. S. Endler, C. D. Johnson, P. H. Petersen, A. J. Sussman, and L. R. Sweetman.

V. SELECTED REFERENCE

Brick and Clay Record, **93**, No. 2, 26 (1938).

Washington, December 7, 1938.

The *National Bureau of Standards* was established by act of Congress, approved March 3, 1901, continuing the duties of the old Office of Standard Weights and Measures of the United States Coast and Geodetic Survey. In addition, new scientific functions were assigned to the new Bureau. Originally under the Treasury Department, the Bureau was transferred in 1903 to the Department of Commerce and Labor (now the United States Department of Commerce). It is charged with the development, construction, custody, and maintenance of reference and working standards, and their intercomparison, improvement, and application in science, engineering, industry, and commerce.

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